

Herefordshire Archaeology
Planning Services
People and Places Directorate
Herefordshire Council

**New Weir Forge,
Whitchurch,
Herefordshire:
A Report on Excavations
in 2009 and 2010**

NGR: SO 5589 1556

Herefordshire Archaeology Report No 306

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Herefordshire Archaeology is Herefordshire Council's county archaeology service. It advises upon the conservation of archaeological and historic landscapes, maintains the county Sites and Monument Record, and carries out conservation and investigative field projects. The County Archaeologist is Dr. Keith Ray.

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Herefordshire Archaeology Report No. 306

Herefordshire Archaeology, December 2011.

Summary

This report describes the rationale, extent and results of excavations carried out at New Weir Forge, Whitchurch, Herefordshire by Herefordshire Archaeology in 2009 and 2010. During the 18th century the site was an Iron refining forge, though it appears that this phase was built on earlier foundations (and in part on earlier slag heaps).

Six areas were investigated based in part on surface evidence and partly on the results of a geophysical survey carried out prior to the excavation. The results of this survey are presented. Remains associated with the former use of the site as an iron forge were revealed during the excavation including one area that may have been the site of one of the hearths. A later building appears to have been used as a smithy possibly after the main works had gone out of use. Other remains were identified as possible water management features and storage areas. There is some indirect evidence for an early phase of blast furnace smelting on the site.

Samples of industrial residues (slags) were collected, these have been assessed and the results are included here. Some of the historical and documentary evidence for the site is also presented as is an assessment of the potential importance of the site for ironworking research and study.

Disclaimer: It should not be assumed that land referred to in this document is accessible to the public. Location plans are indicative only. NGR's are accurate to approximately 10m. Measured dimensions are accurate to within 1m at a scale of 1:500, 0.1m at 1:50, and 0.02m at 1:20.

Figures contained within this report contain material from the Ordnance Survey. The grid in this material is the National Grid taken from the Ordnance Survey map with the permission of the Controller of Her Majesty's Stationery Office (100024618 2008). This material has been reproduced in order to locate the site in its environs.

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Introduction

This report provides an account of archaeological excavation at New Weir Forge, Whitchurch, Herefordshire. New Weir Iron Works was essentially an iron-working forge for refining and processing cast (or pig) iron produced at various nearby furnaces. It worked from at least 1570 and up to the early 1800s when it is thought to have gone out of use. A reasonable amount of documentary evidence survives for the site from which a basic history can be gleaned. This report describes two seasons of excavation on the site carried out between the 20th April and the 15th May 2009 and the 4th May and 28th May 2010.

The project was organised by and funded through the Overlooking the Wye project. This Landscape Partnership Scheme was designed to improve and promote the enjoyment, understanding, accessibility, involvement, conservation and management of the historic environment in the landscape of the lower Wye Valley. The Overlooking the Wye project was initiated by the Wye Valley AONB and was supported by the Heritage Lottery Fund with the objective of carrying out a variety of projects at sites within the Wye Valley between Ross-on-Wye and Chepstow.

One purpose of the excavation work was to provide information to be used to inform the future management of the site through a Conservation Management Plan. For instance what is the state of preservation, have most of the remains been robbed for building stone or are structures and deposits relatively well preserved below demolition/collapse rubble and alluvial material. Another aim was to involve local volunteers in archaeological investigative works and to provide information for interpretation of the site.

Another important aspect of the project was the research element. New Weir was predominantly a charcoal fired forge and little work has been carried out on forges of this type and date, any information gained would make an important contribution to industrial studies both locally and nationally. Many similar sites continued to be reused and adapted as various improvements and processes came and went. In the case of the New Weir Forge however the site had gone out of use by the end of the 18th century and the site was not reused or substantially modified after that time. This cessation of activity and its rural location has given the site potential to have features and deposits preserved that at other sites may have been destroyed by later use and disturbance.

Prior to excavation the works survived as a complex of earthworks with some visible masonry depicting buried wall lines and some reasonably well preserved masonry features consisting mainly of revetment walls and buttresses, some standing to as high as 3m. It is thought likely that much stone from the former buildings has been removed from the site to be used in nearby domestic buildings.

In order to guide the location of excavation trenches, and to make best use of the resources allocated, a report was commissioned prior to the excavation to assess the historical background and significance of the site. A geophysical survey was also carried out to try to identify significant magnetic anomalies that might indicate the sites of forge hearths or other areas of activity and provide a focus for the excavation. Both reports are included as appendices.

Location and Geology

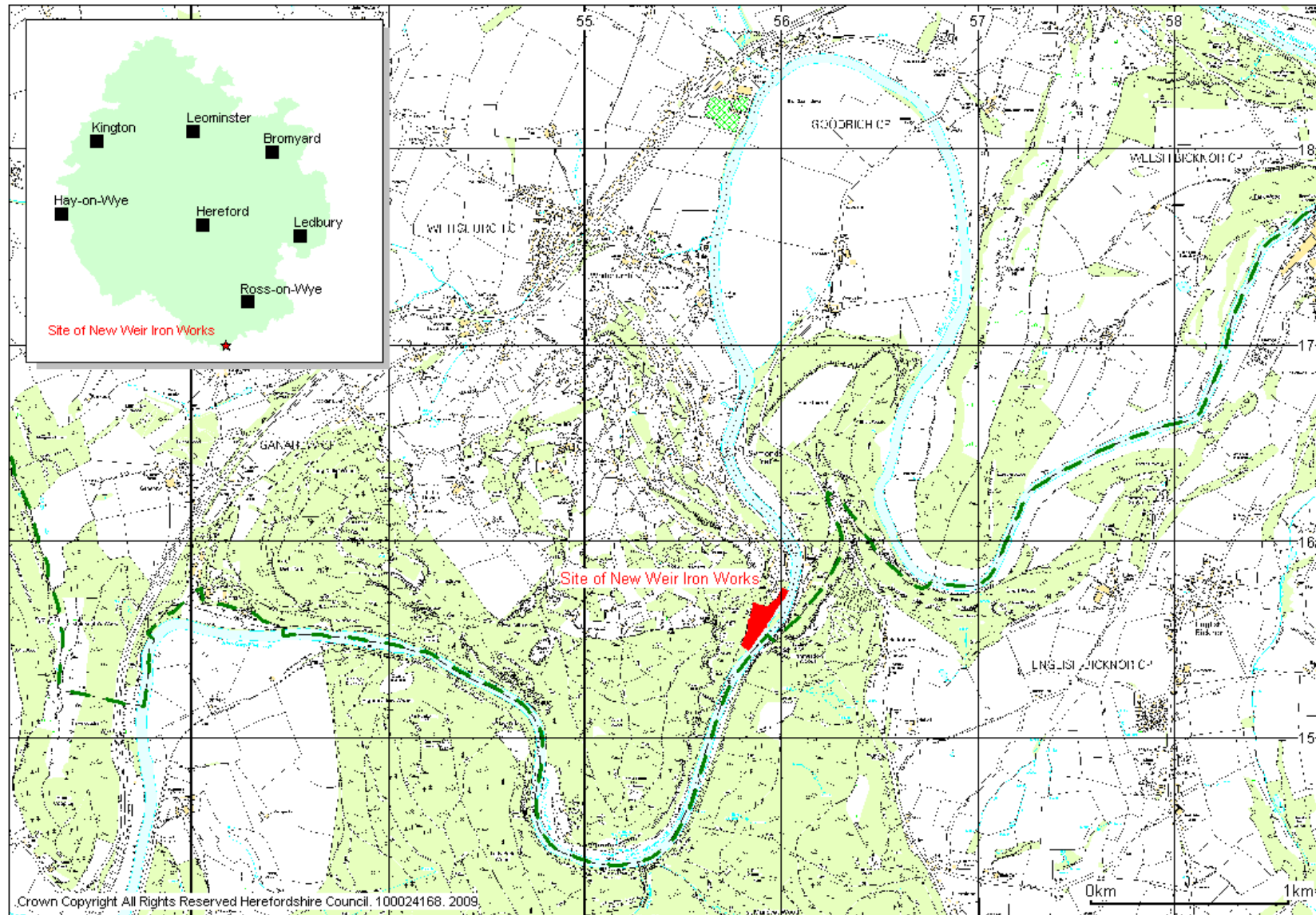


Figure 1 Site Location

Location

New Weir Iron Works is located on the west bank of the River Wye, at SO 5589 1556 a few hundred yards downstream from the scattered settlement of Symonds Yat West (figure 1). It lies in the parish of Whitchurch, Herefordshire, between Monmouth, 6km to the southwest and Ross-on-Wye 9km to the northeast.

Geology

The area lies at the junction of numerous geological layers. The site is characterised by the carboniferous limestone series of the upper old red sandstone. The lower slopes consist of the lower dolomite series and above this is a significant limestone band. The base of the site is marked by the edge of the River Wye so consists of alluvial deposits (British Geological Survey 1989).

Soils

The soils of this area are the Crwbin series, part of the Rankers group and consist of fine silt over carboniferous limestone.

Geomorphology and landform

The site of New Weir Iron Works lies just within the northern, upstream, end of the Wye Gorge. The course of the Wye here is thought to have arisen when a large river meandered across a floodplain of soft sediments and then cut down through successive layers of rock as land levels rose, the result is the spectacular Wye Gorge. The river runs some 120m below the plateau at this point. On the east side the cliffs are virtually vertical whilst on the west they are slightly less steep. The distance between the plateaux at the top of the gorge is a mere 400m. The river is confined within a narrow course leading to dramatic rises in water levels in times of flood. The constricted nature of the river at this point combined with geology and later man made influences has resulted in a stretch of shallow water rapids.

The limestone geology has given rise to some classic Karst features including isolated pillars of rock that tower above the river and also a number of caves some of which are known for their Pleistocene and later archaeological deposits.

Historical and Documentary Evidence

It is not the intention to review the documentary history of the site in great detail. This has been partially carried out with varying degrees of agreement in previous publications and commissioned reports (Williams, 2007 and Priestley, 2008 for instance). There has been some confusion between a forge and furnace at Old Weir, 3km upstream at Whitchurch, and the iron works at New Weir. Research into the history of the site is continuing via a private researcher and it is expected that a more definitive history will be published in due course (This was in fact published as this report was nearing completion, Lowe, 2010).

The documentary evidence available concerning New Weir includes letters, leases, newspaper reports and adverts, tourist descriptions, paintings and maps. One of the earliest descriptions in 1695 sets out the function and extent of the works and associated buildings it states that -

“The Earl of Kent, upon an old foundation has lately built his forge, which is one of the best in England, having two hammers and three chaferies or fineries which can work in the driest time of summer. There were besides, a dwelling house for a tenant, stables, warehouse and outhouses and several dwelling houses lately built for above 30 families” (Van Laun, in Williams, et. al. 2007).

In 1684 George White had leased the site and it is further reported that in 1706 he constructed a slitting mill on the site (Rosalind Lowe, pers comm.). A slitting mill was used to cut iron plates into square section rods for making artefacts such as nails or providing the raw material for wire making. At some point this may have been converted to a rolling mill for producing iron plate as by 1811 the lease was being advertised in the Hereford Journal and the Gloucester Journal. It is described as “A capital Iron Forge with two hammers, three fineries, a chafery, an excellent rolling mill, a commodious dwelling house, divers cottages, stables, outhouses and all other necessary conveniences.”

Two surviving surveys are extremely important and informative. In 1758 “An Exact Map” of the site was produced by Daniel Williams (figure 2). The detail shown is wonderful. The layout of the works is shown including the forge and slitting mill, Mr Partridge’s house, garden and orchard (John Partridge “Ironmonger of Ross” had taken over the lease in 1753). Three water wheels are depicted on the works buildings. The weir, lock and capstan for hauling boats upstream through the lock are also shown above the works.

In 1779 a plan drawn in connection with a proposed canal to ease navigation past the weir and the shallows below it again shows the forge and slitting mill (figure 3). The building behind these is presumable the house. Only these three are outlined in bold and it appears that the other constructions along the riverbank were not substantial buildings but possibly open yards, working areas or lean-tos. An important feature on this plan is the double outlet from the slitting mill wheel pits and a semicircular buttress of masonry between the two. This confirms that the mill had two wheels. These features are still visible in the river bank and bed and corroborate the site of the slitting mill.

It is also clear from these sources that new weir is a multi phase complex. There is the reference above to it being built on “old foundations”. There is also a report that states that in 1706 part of the works – the storehouse – was erected on a parcel of land called “Sinderhill”

suggesting construction on pre-existing slag heaps (Rosalind Lowe, pers comm.). This is also reflected in the archaeological evidence (see trenches 4 and 6 below).

In the 18th and 19th centuries the area around New Weir became well known for its landscape and natural beauty. The lower Wye was included on many “tourist” itineraries. During this period a number of paintings and drawings were made that depict the Iron works and provide tantalising glimpses of the site at that time. It must be accepted that many follow the romantic tradition and are plainly inaccurate or fanciful. However used with caution they can provide invaluable information.

A pencil sketch by Joseph Powell of about 1810 (figure 4), published by Coates and Tucker (1983, 56-57), is in a different artistic tradition and appears to be an accurate depiction of what was actually there. Although Coates and Tucker state that Powell, using artistic licence, has switched the left bank of the river to the right, the drawing is in fact correct and looking not as they thought across the river at the forge but across the forge pond, note the grills which were to prevent debris entering the wheel pits rather than protecting the outlets. The angled revetment on the right (the bow of the boat is tucked in behind it) also matches perfectly with the angled depiction of the forge pond on the 1758 map (figure 2). The building to the left is the slitting/rolling mill. It would have had two water wheels, the right hand one is shown. The area on the right appears to be a storage and quay area complete with steelyard balance. According to the plans available the building on the right of this area should be the forge. This depiction is particularly important in the interpretation of the excavation results in trench 1.

The painting by Michael Angelo Rooker is also useful here in that it confirms the use of the leat by boats (figure 5). The slitting mill, gable end on to the river, is the first building on the left.

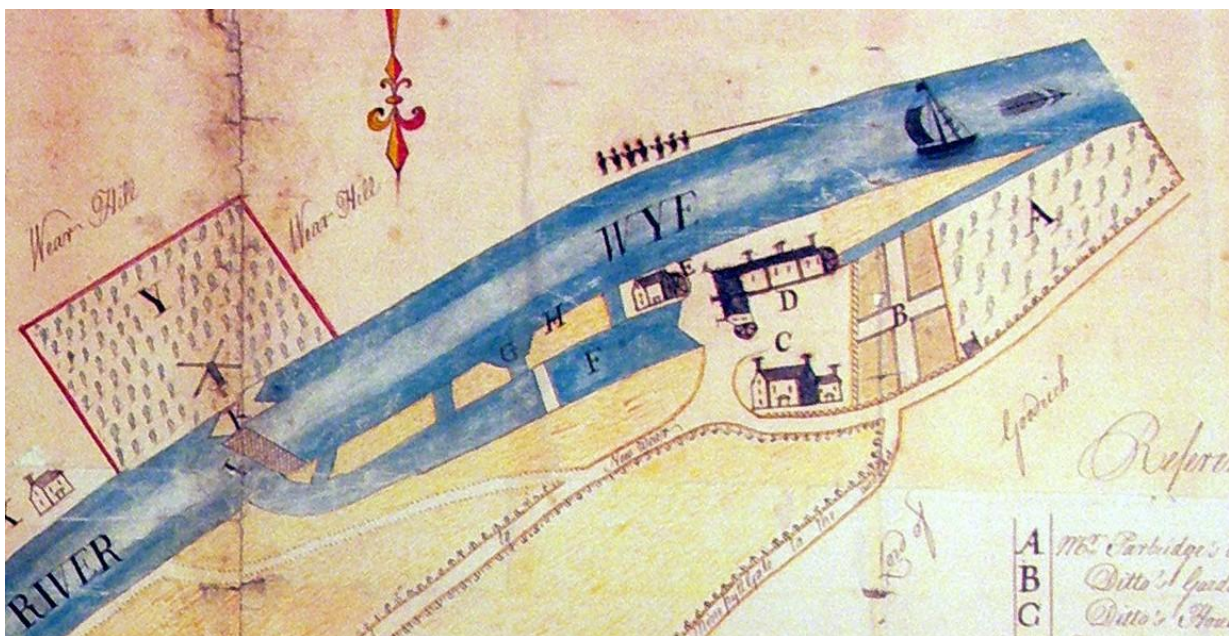


Figure 2 Detail of the 1758 Survey by Daniel Williams, A - Orchard, B - Garden, C - Mr Partridge's House, D - Forge, E - Slitting mill, F = Forge pond.

Reproduced courtesy of The Nelson Museum and Local History Centre, Monmouth



Figure 3 Detail from the 1779 Survey by A Whitworth. *l* is identified in the key as the slitting mill and *m* as the forge.

Reproduced by courtesy of The Herefordshire Record Office

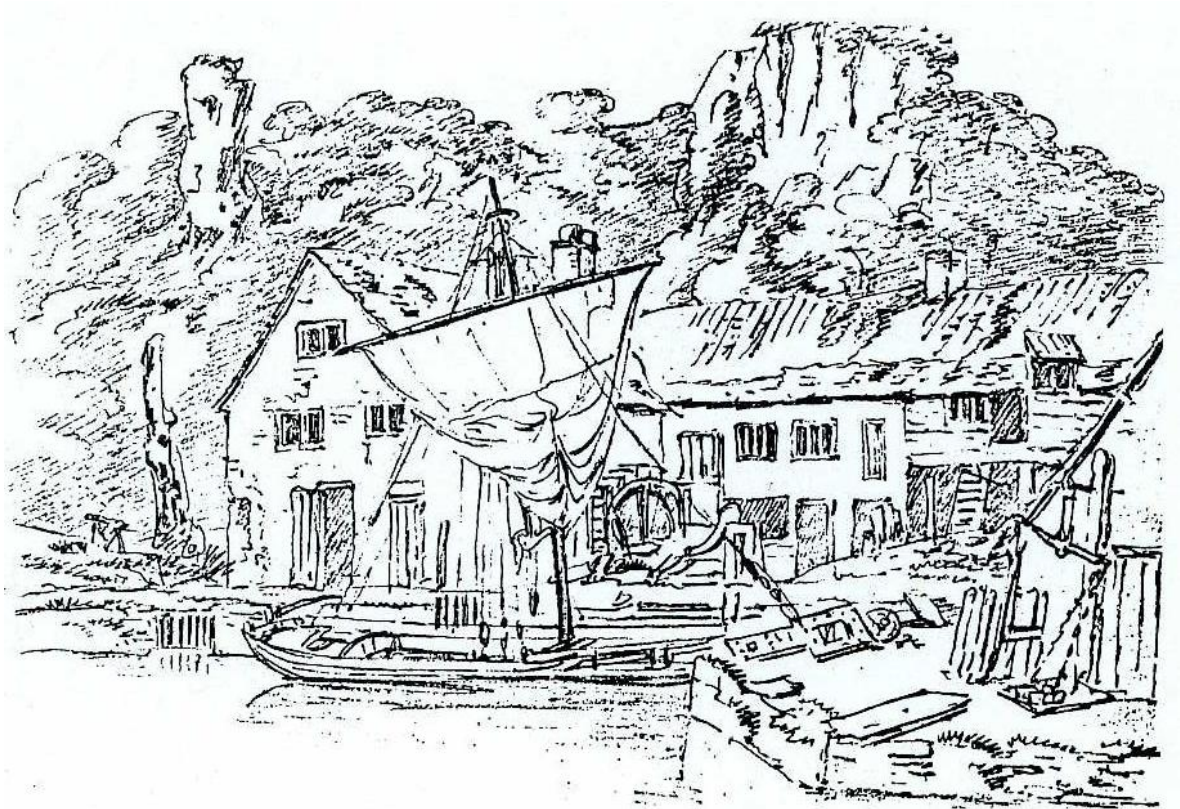


Figure 4 A sketch of New Weir in about 1810 by Joseph Powell (in Coates and Tucker). The view is across the forge pond, the building with the water wheel is the slitting / rolling mill. It would have had a further wheel on the left hand side.



Figure 5 A late 18th century (c1783) illustration by Michael Angelo Rooker showing a boat using the leat to access the iron works

Reproduced courtesy of The Nelson Museum and Local History Centre, Monmouth

Historic land use

Apart from those features directly associated with the iron-working site no other archaeological features or finds are recorded from the site. Close by however are a number of other industrial sites some probably associated with the iron works, for instance, limestone quarries, charcoal platforms and a number of trackways. The weir has completely disappeared and even its original location is not entirely clear. The rapids are now an important area for white water kayaking and engineering has taken place and the river bed altered to improve this. The lock and associated features on the other side of the river were probably completely destroyed at the time of the construction of the railway line that runs just above the river and is now a forest track and footpath.

It is reported that two boats were constructed at New Weir, one in 1808, the 37 ton barge “Betsy”, the other in 1856 the 24 ton trow “Monmouth Trader”. They were presumably able to use the works or at least the leat/forge pond as a dry dock. The former would seem to confirm that the works were already out of use by around 1800.

One of the largest salmon ever caught on the Wye was landed at New Weir in 1769, it weighed 56lb pounds. This was only surpassed in 1923 when Miss Doreen Davey caught a 59½lb fish at Winforton.

Physical Remains

Although very little detail is visible on the site the composition of the works is described in the various documentary sources and the basic layout is fairly clearly depicted in the historic maps and plans. It is therefore possible to interpret the earthworks fairly accurately. These are laid out schematically in figure 6.

The main leat (A), forge pond (B) and tailrace (C) can all be readily identified. They survive as broad, shallow depressions. They are heavily silted up, and the original depth of the features is unknown. On the west side of the leat and forge pond are the remains of revetment walls, and the tailrace is marked by an impressive stone arched culvert where it emerges from under the works. The exact configuration of wheels and water management is not clear, but the water must have run through a culvert below the works, possibly powering wheels as it went, before emerging into the tailrace.

The most visible building remains on the site are those that are thought to be the owners/tenants house (D). This is built into the hill slope and the back wall of the building and buttresses, again comprising sandstone masonry, act as a revetment wall and survive to a height of over 4.00m. The base of this surviving portion, is at the same level as the works, and may have functioned as storerooms or offices, the accommodation proper perhaps being on upper floors. The terraced gardens and area of the former orchard (see maps in figures 2 and 3) are recognisable on the ground today as earthwork platforms and collapsed walls.

Between the house and the river lay the main works comprising the forge, slitting mill (later rolling mill) and ancillary buildings. Evidence from the two historic maps places the slitting mill (E) at the northeast end of the main complex, in an area between the forge pond to the west and the river to the east. The site of the building is represented now by a low earthwork mound, the flanking wheel pits by slight hollows and the tail races and associated masonry are visible in the river bank and bed below.

The forge (F) occupied the area in the centre of the complex but the earthworks here are the least comprehensible. The remains of the probable ancillary buildings are raised above the general level of the works ranging along the river bank and survive as prominent earthworks with wall lines showing intermittently at or only slightly above ground level. In places individual buildings or rooms can be identified and part of a flagstone floor is exposed by riverside path erosion. The tailrace arch and adjoining wall that marks the southern extent of the forge area are extremely well preserved. The wall survives to a height of about 3.00m.

Riverside revetment walls (K) separated and protected the works from the river. These have been interpreted by some as also doubling as a riverside quay. This is unlikely as there is a significant difference in height between the building level and river level (c 4.00m) and the presence of the shallows here would anyway have precluded this use. All the documentary evidence suggests that boats used the leat and forge pond to enter the works for loading and unloading (see above).

On the slopes above the site are the remains of the cottages referred to in various documents. This particular one (J) appears to be tripartite with a yard or small garden area cut into the hill slope behind.

Another major feature of the site is the large deposits of slag and other waste. The area surrounding the various structural elements, the river bank and in places the river bed itself are solid deposits of slag. Hearth bases and structural material including brick and stone are visible within the eroding riverbank. This material extends downstream well beyond the area of the main works complex.

The trackway (L) running immediately above the site is thought to be associated with the iron works. This and other tracks are shown on the historic maps. In character the track is reminiscent of a tramway; it is metalled with a consistent surface though as no sleepers or other features are visible it may only have been a cart track (This metalling may be later improvement carried out by the Forestry Commission for woodland management purposes).

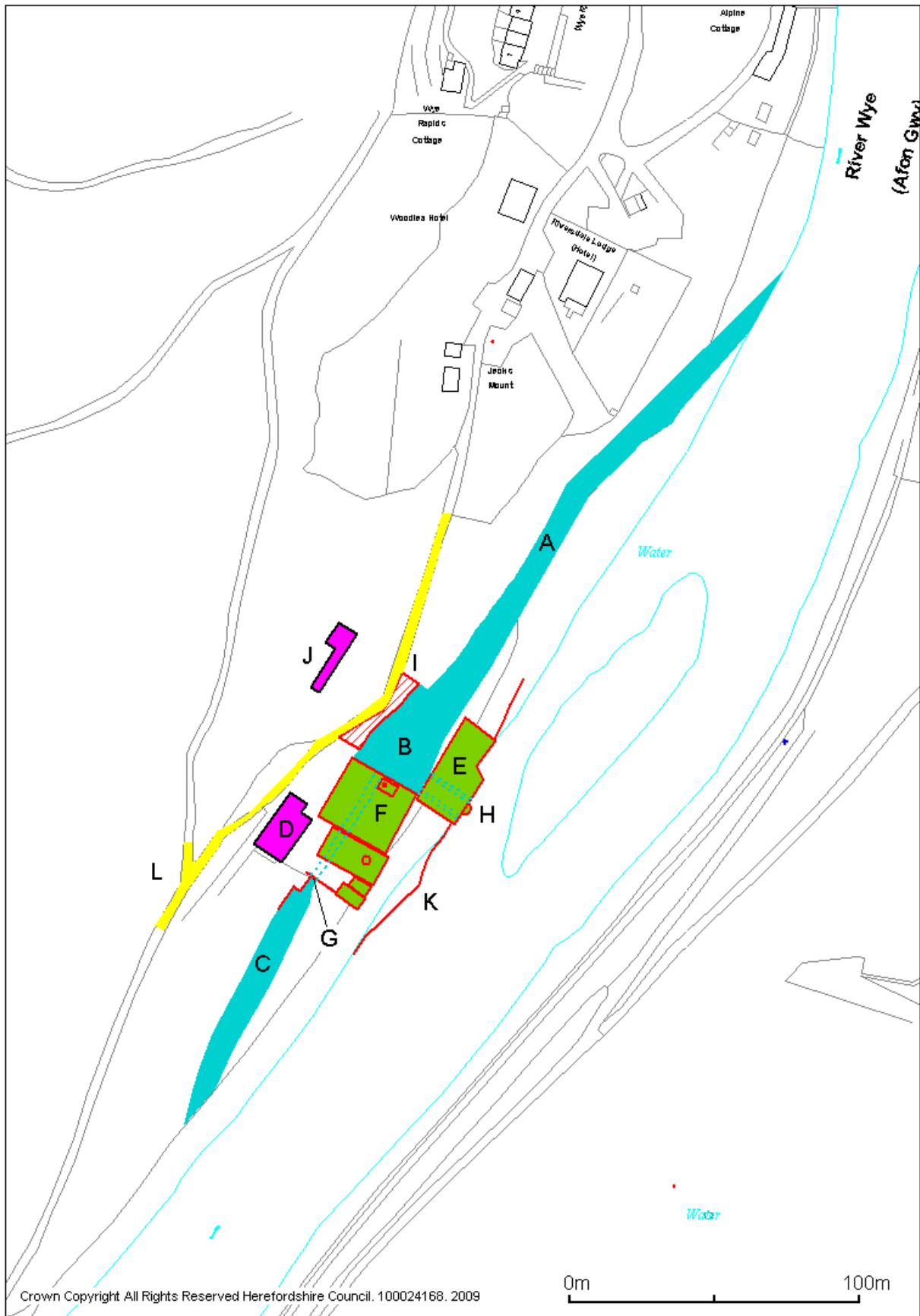
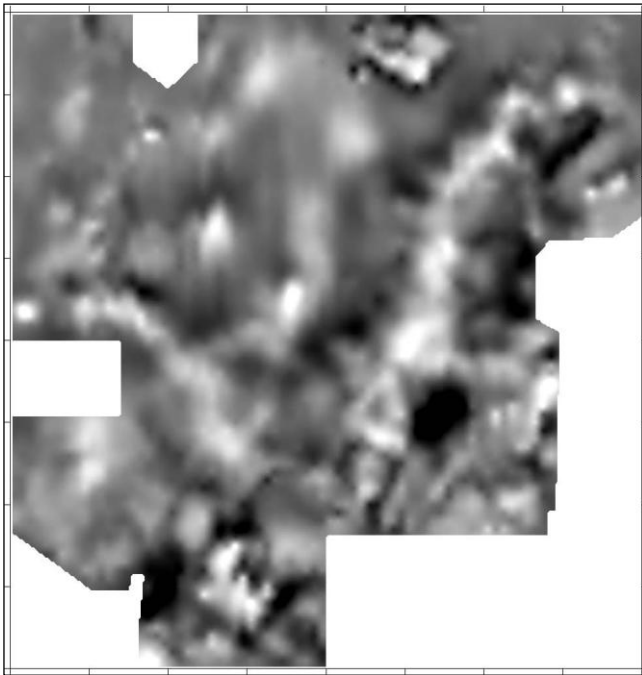


Figure 6 A (very) schematic plan of New Weir Iron Works

Geophysical Survey

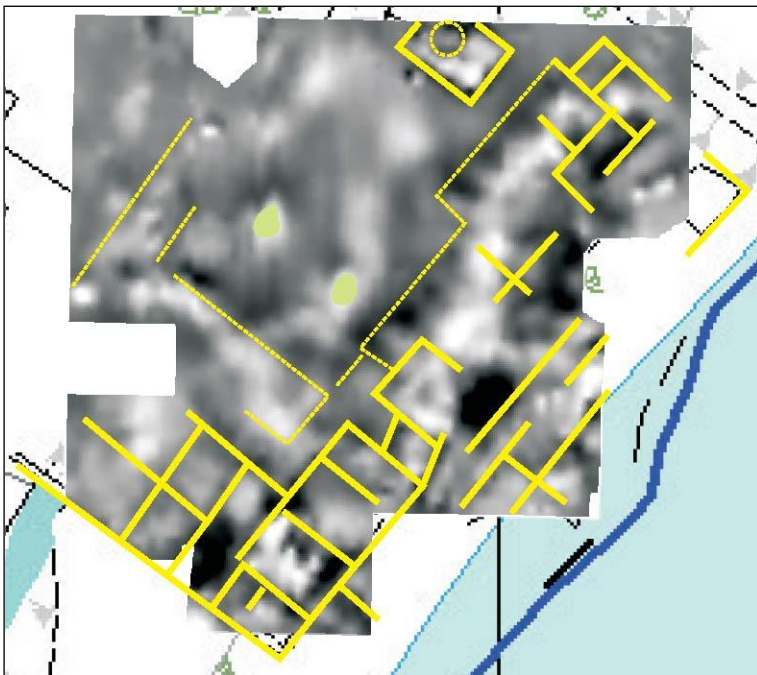


Prior to excavation geophysics was employed to try to define possible hearth sites or other areas of high magnetic susceptibility. These may have indicated areas of activity and would have provided potential foci for excavation. A sample area of the site was selected for survey. This comprised the central area of the site which from documentary sources and physical remains seemed most likely to contain the working hearth areas.

The results (Figure 7) are understandably dominated by the large amounts of residual slag on the site. However the contrast between this and the non magnetic stone walls provides unusually good quality data for an industrial site (Young, 2009).

Figure 7 Geophysical survey (paler areas are those of high magnetic readings, wall lines – non magnetic – show as darker areas)

One apparently well defined building with high magnetic readings within the interior was identified at the northern edge of the survey area (Figure 8). This was partially visible on the ground in the form of a distinct earthwork mound the southern side of which was defined by a well constructed wall. This feature



had previously been tentatively identified as part of the forge pond dam. The walls of a potential further building range were identified in the south-eastern part of the survey area. A particularly high magnetic signature was recorded within one “room” at the south end of the range.

The north-east to south-west trending linear magnetic spread is thought to be comprised of a slag dump on the western side of the range of buildings known to have occupied the area along the river bank. Two large magnetic anomalies are present within the area defined as the forge on historic maps

Figure 8 Geophysical survey with putative wall lines overlaid



Figure 9 Trench Locations. *The size and shape of the buildings is very approximate and for purposes of location only.*

Methodology

Six trenches were opened in various areas of the site (figure 9). It was recognised that full excavation of, for instance, an identified building such as the slitting mill was not achievable given the time and resources available, and in any case this approach would only give us a picture of one area of the site and probably only in its latest phase. It was decided instead to test a range of visible features and areas of high magnetic anomaly identified through the geophysics. Four areas were identified in year one, two of these were continued in year two and these were supplemented by an additional area in year two and a small test pit in year one. All trenches were opened and excavated by hand.

The stratigraphic sequences, features and structures exposed in all trenches during the excavation were recorded by running context and scale drawings (1:20 for plans and sections). Context sheets were completed for all identified contexts. Photographic records were also made on digital media during the excavation.

Excavation Results

Trench 1 (11.10m E-W x 7.80m N-S Max)

As outlined above Trench 1 was located to examine what appeared to be a small rectangular building with a significant magnetic reading within its interior. Prior to excavation this appeared as a low earthwork mound about 9.00m east-west by 4.50m north-south and 1.20m high. Walling was visible on the south side but no other structure was apparent.

On excavation it was found that many of the features and deposits in this area in all probability relate to later smithing activity that took place in what appears to be a makeshift building and may not be related at all to the main works on the site. They could be associated with local smithing requirements or just a small workshop perhaps related to activity such as the boat building referred to above. Dereliction, probably some deliberate demolition and subsequent robbing has left only fragmentary evidence for interpretation but even with these caveats it seems that the building was never very substantial and may have been a simple lean-to constructed mainly from timber on a sleeper wall.

Excavation has shown that the location of this “smithy” is in an area shown on all the documentary images to have been an open area between the forge building to the south and the forge pond to the north (Figures 2 and 4). Figure 4 in particular shows it around 1810 being used as an open working area for storage and processing, including weighing. It was probably used as a quay and may have been one of the main areas for loading and unloading boats. The area was defined to the north by the forge pond revetment wall (1004) and on the south by a substantially built wall (1003, figure 10).

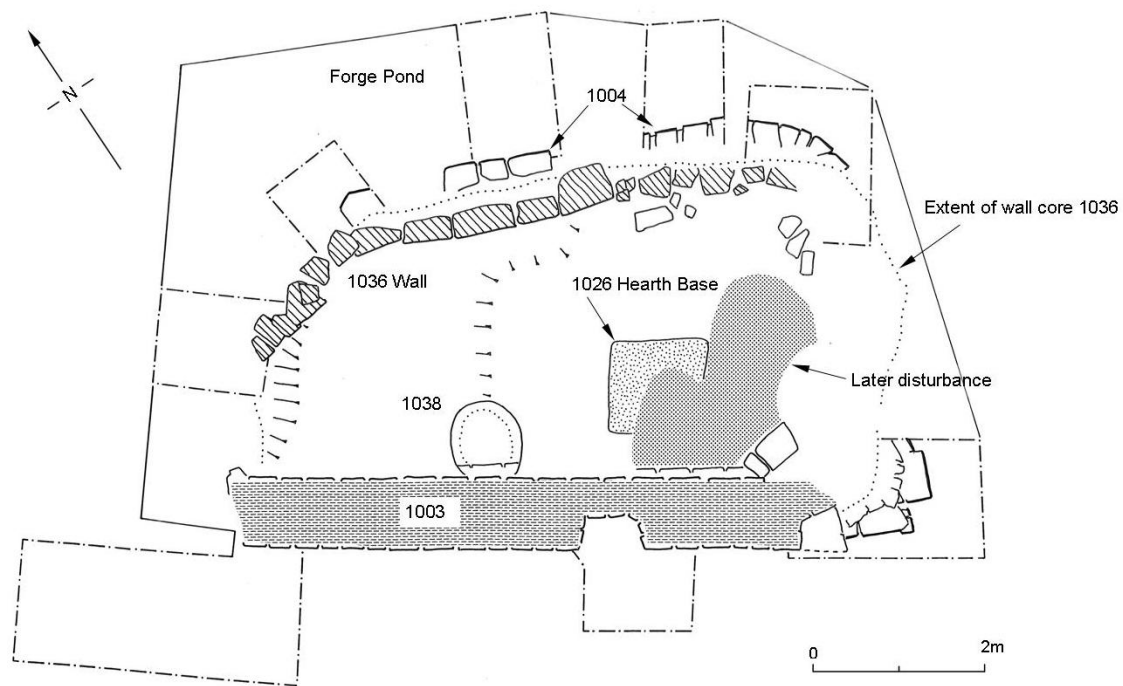


Figure 10 A composite plan of the structures and features in trench 1 mainly relating to building 1005

The dam wall and open working / quay area (1004, 1034, 1037, 1035, 1031)

The earliest structures within trench one were found to be wall 1003 and the dam retaining wall 1004. Between the two a deposit of bright yellow / orange clay (1034) formed the bulk of what could be described as the dam bund material proper. This clay butted the well built and coursed lower levels of the north side of wall 1003 which projected on the north side in the form of a foundation and also lapped up the wall some way. The quality of the masonry construction of the north side indicated that this wall had clearly been built prior to the clay being deposited. Conversely the clay formed the matrix and core of the dam wall 1004 to the north which had no rear facing clearly acted as a revetment wall for the clay bund indicating that they were of the same building phase. The structure and evolution of wall 1003 is discussed further below.

Above this clay a stony compact horizon (1037) formed a hard standing. Working debris mixed with sand and pebbles had accumulated on this surface and contained concreted (by rust) iron fragments, dark slag, coal, charcoal and fragments of green blast furnace slag (1035 and 1031). The upper layer 1031 was also rich in fine spheroidal hammscale and some flake hammscale. These deposits were laminated and had clearly accumulated gradually over time. These were in turn partially overlain by the later hearth structure 1026 and its associated floor 1027 (see below).

Wall 1036, Building 1005

Overlying this working debris deposit 1035, and laid onto it with no foundation courses or trench, was the remains of a wall 1036. It survived only on the north and north-west of the area (figure 10), nowhere more than three courses deep, no mortar was present and surviving core material suggests that the upper courses of the forge pond wall (1004) may have been utilised for its outer facing. It defines an area or room measuring approximately 8.00m (max) east west by 3.50m (max) north south.

The fragmentary nature of the wall is probably the result of stone robbing but although it is difficult to determine its exact original form it does not appear to have ever been a substantial wall and may represent a simple dry stone foundation wall for a timber framed or planked wall. It may even have been a lean-to building. The more substantial wall 1003 certainly formed the southern side of the building 1005.

The Hearth (1026, 1027, 1028)

Within the south east quarter of building 1005 were the remains of a structure that may be interpreted as a hearth (1026). The site for the hearth appeared to have been levelled prior to its construction by a deposit of distinctive red clay (1028). This was filling a hollow under the eastern half of the hearth the shape of the cut suggested that it may have been previously occupied by a structure of similar character to the hearth above, perhaps an earlier hearth. Adjacent to the cut and within the floor deposits 1035 was an iron plate measuring 0.44m by 0.70m and approximately 0.02m in thickness, one corner was neatly cut away and this cut coincided with a neat deposit of coarse crystalline sand and stone fragments measuring 0.20m by 0.20m. This is interpreted as the degraded base of a stone block that may have formed part of the superstructure of the earlier hearth. Both the iron plate and the remains of the stone block were overlain by floor debris deposits 1035 and 1031.

Overlying all these deposits was a further deposit of coarse crystalline sand and sandstone fragments 1026. The south east corner had been removed by later disturbance and disturbed by tree roots but the deposit defined an area measuring 1.00m north south by 1.10m east west. This deposit is again interpreted as the degraded remains of the stonework base of the structure of a hearth. Butting this deposit was another sandy pebbly working floor deposit (1027) which contained abundant tiny spheroidal hammerscale and some flake hammerscale and dark slag. It also contained coal, charcoal, some iron ore and grey/blue slag fragments.



Figure 11 The site of the smithing hearth 1026 defined by the degraded base of the stone structure, the upper right part has been removed and disturbed by later disturbance and tree root growth.

1.00m to the west of the hearth was a pit (1038) cut 0.35m into the dam bund material (1034). Although its purpose is unclear it is possibly the socket for a timber base for an anvil. These were often set on timber bases to help absorb the impact of constant hammering. The fill of the pit was mixed loam flecked with abundant lime mortar probably reflecting infilling at the time of deliberate demolition and/or stone robbing.

Further deposits of red clay (1011) up to 0.12m in depth had been used to level up the working area around the putative anvil base and may reflect repairs to the floor where this had been eroded through extended or heavy use. Further general working debris (1009) had accumulated over the whole area prior to dereliction and probable demolition.



Figure 12 Trench 1 at an early stage of excavation. The facing wall of the forge pond can be seen in the deeper excavation areas. This is separated from the walling above by deposits of working debris. The back wall of the building is formed from what is probably the outer face of the northern wall of the forge building. This picture also illustrates the nature of the earthworks representing the former buildings of the forge complex.

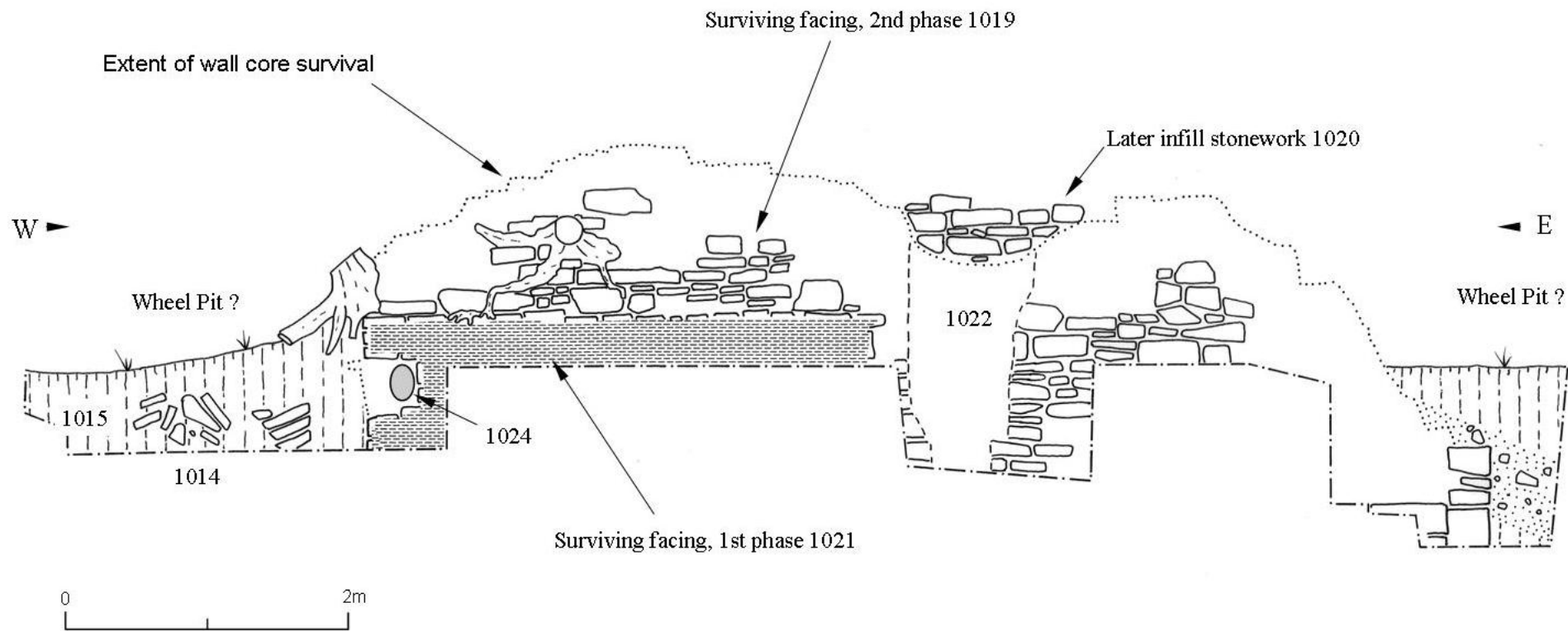


Figure 13 Trench 1, south facing section of the surviving multi phase wall

Wall 1003 (1019, 1020, 1021, 1022, 1023, 1024)

The well built wall 1003 marks the southern extent of both the working area and subsequently the later building 1005. It seems though to relate to activity and probably a substantial building lying to the south in the area where documentary evidence suggests the main forge complex should lie. As described above the quality of construction shown on the northern side indicates that it was built prior to the deposition of the clay deposit forming the forge pond dam and revetted by the forge pond wall.

Two main phases of construction were apparent (figure 11), the lower 1.00m, about eight courses, were constructed from neatly dressed sandstone. Above this the intermittently surviving facing was of irregular rounded sandstone blocks and cobbles. The mortar for the two phases was also completely different the earlier phase using a mid brown lime mortar with an aggregate of mixed sand and charcoal. The later mortar was a clean white lime mortar with no visible inclusions.

The total length of the wall was 7.30m and it was 1.00m wide, the total height exposed by excavation was 3.00m. The length as excavated appears to have been the original extent as both ends were finished with neat faced masonry descending into what may be wheel pits. In neither case was there any sign (at the excavated levels) of southerly returns. The substantial masonry facing of the east end was clearly part of the forge pond wall construction (see figures 10 and 13) but whether actual wheel pit or still part of the pond or a sluice arrangement is not clear. The areas in question were choked with fallen masonry within a matrix of mortar and alluvial silts. The density of rubble and the depths of excavation did not permit further exposure of the features and one must suspect that the answer lies another 2 or 3 metres below the excavated level. Amongst the collapsed masonry at the eastern end of the wall was some quantity of distinctive honey coloured dressed limestone blocks (1014) this stone was not encountered anywhere else during the excavation or seen anywhere on site. The increasing density of mortar with depth within 1015 might suggest stone removal linked with demolition.

In the south face of the wall towards the eastern end was an area where the wall had been deliberately cut into (1022). This coincided with a gap in the top of the wall that was later patched with five (surviving) courses of infill stonework (1020). This feature may have been cut to take the timber member of a piece of machinery perhaps associated with wheel driven bellows or hammer. A neat hole through the western end of the wall appears to have been a deliberate feature of the original construction. It is at a depth where it would be blocked on the north side by the clay of the dam (1034) and therefore it probably relates to an earlier phase of use.

Trench 2 (1.80m x 2.80m)

Trench two was opened to explore a curving length of walling visible as part of the masonry remains on the site (figure 14). It was one of the more intriguing pieces of masonry though it was (and is) unclear what it represented.

The keyhole nature of the investigation makes definitive interpretation difficult but it is possible that this structure was associated with water management within the works, the shape of the walling serving to deflect and turn the water perhaps within a channel or sluice that was partially lined (and floored) with timber. An alternative explanation is that it is thus shaped to accommodate a specific piece of machinery within the forge or other working area.



Figure 14 Masonry remains visible above ground prior to excavation



Figure 15 Trench 2 on completion of excavation

The masonry element consists of a section of curved walling with a maximum surviving length of *c*2.00m (figure 15). At the south western end it terminates in a corner where the wall turns to the south. The northern end of the wall continued beyond the excavation area. The curving section survived to a height of around 1.50m at its base was a straight section of wall consisting of three to four courses that cut across the arc of the curve. This was not simply a foundation but rather took the form of a shelf. The function of this is unclear but was possibly to support a timber floor or joist.

A low wall (2005) running west from the south-western corner of 2002 is the same height as this shelf and may similarly have been a support wall of some kind. It was very roughly built with up to eight uneven courses of random angular sandstone blocks.

Within the trench the undisturbed natural clay sub-soil was encountered at a depth of 0.90m below present ground level. Above this was a layer of mixed sand and clay containing slag and iron fragments (2009) between 0.19m and 0.27m deep. This was recorded in the field as a possible levelling layer and on its surface was a fine black sediment deposit 2008 that may have been laid down under standing water. The material above this consisted of stone fragments in a matrix of alluvial material this deposit clearly represented a phase of demolition or collapse.

The channel was subsequently blocked by the construction of the wall 2005 (figure 15). What the function was of this later wall is unclear. It may have been a low supporting wall for a timber lined sluice although there is no clear evidence for this.

Trench 3 (1.5m x 4.00m)

Trench 3 was opened to examine part of a building that geophysics had shown to contain a significant magnetic anomaly. Prior to excavation this was interpreted as either reflecting iron working activity or dumping of industrial residues (slag) within a possibly redundant building.

The latter was shown to be partially correct though not quite the whole story. Heavy duty slag from the forge activity nearby had been used within the building but as sub-



bases to two of three successive floor levels. The residues contained numerous hearth bases and slag runs from the finery process. The raising of floor levels within the building seems to have been deliberate and may have been in response to flooding of the works by the river. The original subfloor, below the lowest floor produced seven pieces of blast furnace slag (see the evaluation of metallurgical residues below)

Figure 16 Successive layers of slag and sooty floor surfaces



The evidence from the floor surfaces suggests the room may have been used for the storage of charcoal. Each “floor” surface comprised a fine black deposit containing charcoal fragments. The need to keep fuel dry would also accord with the successive raising of floor levels. The latest floor level in the sequence was partially covered by a mix of stone and clay roof tile, representing the collapse or demolition of the building.

Figure 17 The latest floor level of the building with clay and stone roof tiles

Trench 4 (8.00m x 3.30m)

Trench 4 was opened in order to investigate the purpose and levels of preservation of a flag stone floor that was partially visible where erosion had occurred on the line of a riverside path. This area is located just to the south of the slitting mill and at the northern end of the building range that runs alongside the river (figure 9).

Excavation was restricted to the removal of the fairly shallow soils and demolition / collapse material overlying surviving structural elements and undisturbed archaeological deposits. In the northwest corner of the trench were the remains of a structure (4006) probably c 2.50m square (figure 19), although the northern part lay outside the area of the trench under a mature sycamore tree (figure 18). This is interpreted as the base of a large hearth. Both the stones themselves and the lime mortar matrix were discoloured by heat. This structure was separated from the flag stone floor (4004) to the east by a kerb of large edge-set stones (4005) that probably served a rudimentary health and safety function.

The extensive surviving flag stone floor had in places been damaged by the industrial activity that had taken place there. The surfaces of the stones were pecked by impact and the cracking and crazing of the stones appeared to have also occurred in association with that activity. The exception was a large single flag stone set against the kerb 4005 (a standing rather than a working area) which although cracked was otherwise unmarked.



The floor and structures lie within a building defined on two sides by the river revetment wall to the east (4007) and a wall to the north (4013) exposed by the footpath erosion. There may well be a wall defining the southern extent of the building but on the western side the trench was connected to trench 6 and there clearly never was a wall on this side.

Some quantity of flake hammer scale up to 2mm thick was recovered from around the hearth structure. This is unlikely to result from rapid heating of iron either in a chafery or in a blacksmiths forge but more likely to result from long heating periods and possibly from the working of billets for working under the hammer to start the plate production process or for working in a rolling or slitting mill (see appendix below).

Figure 18 Flag stone floor with kerb and hearth beyond exposed in Trench 4

Underlying both the hearth structure and the flagstone floor was a lime mortar sub floor (4010/4011) and below this a solid deposit of slag and ash (4012). This material formed a deposit that was present running down the slope to the west and was recorded within trench six (context 6004, see below). It is likely that this represents a substantial slag dump on which the eastern range of buildings was constructed.

Trench 5 (1.00m x 1.00m)

Trench 5 was a simple 1.00m x 1.00m test pit excavated to examine the nature of deposits within the supposed interior of the forge site complex (figure 9). Beneath alluvial deposits 0.37m deep a mixed stone and clay deposit (that may be the weathered top of natural) overlay natural sub-soils at a depth of about 1.00m

At this location at least there are no archaeological structures or deposits.

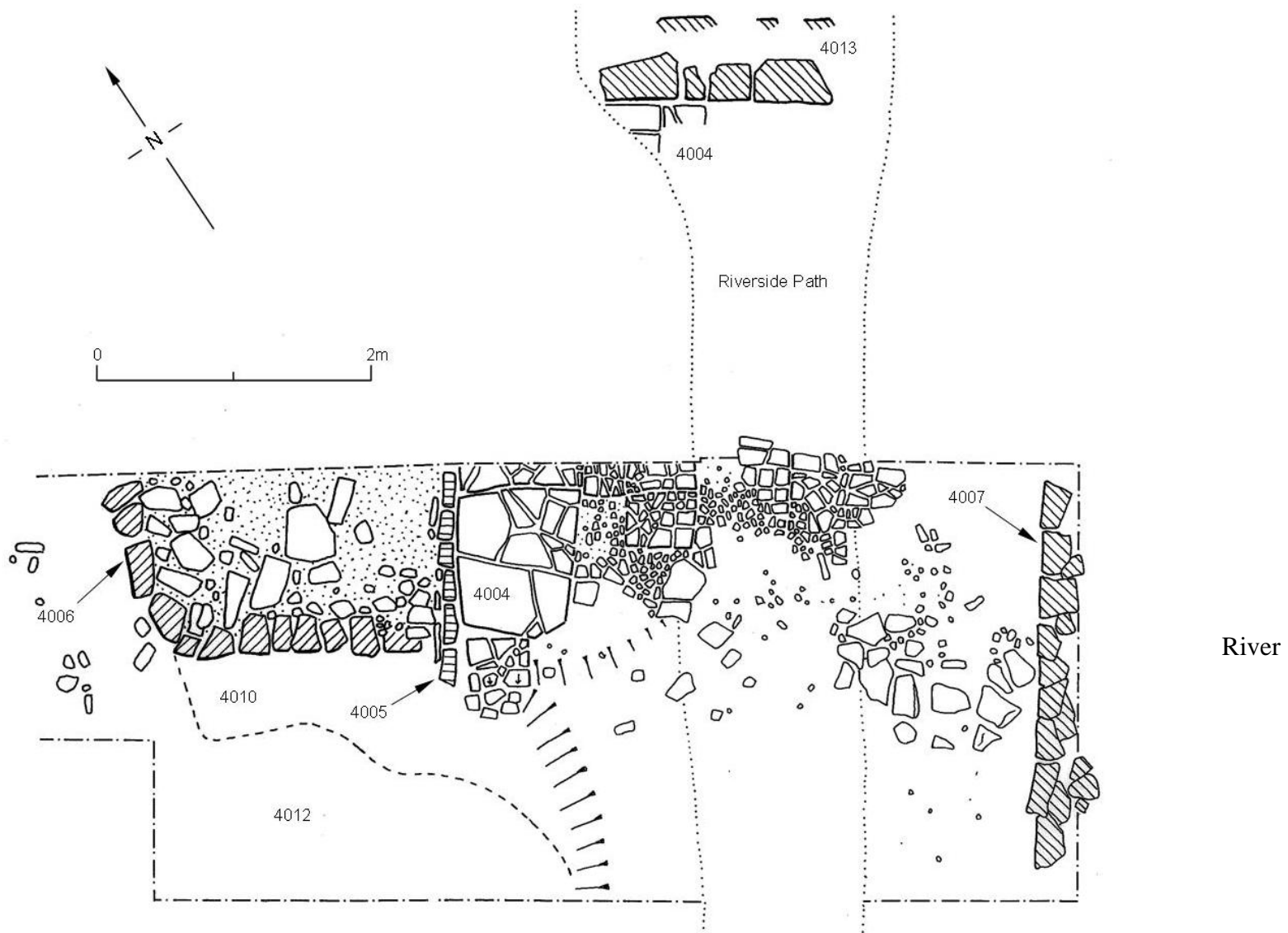


Figure 19 Trench 4 after removal of topsoil and demolition / collapse material

Trench 6 (6.00m x 2.50m max)

Trench six was opened to investigate a length of wall that was visible running north-east to south-west and parallel to the apparent wheel pit to the east of trench 1 (figure 9).



Figure 20 Overview of trench 6, the butt end of the wall can be seen with the wall running off to the north below the beech tree. The southern wheel pit for the slitting mill is top right of the photograph just beyond the small spoil heap

The wall ran north-east from a straight butt end for some 5.50m where it was obscured by a deposit of stone collapse. It is assumed that the wall turned eastward towards the river at this point and formed, or runs parallel to the southern wall of the southern wheel pit of the slitting mill.

The butt end probably represents one half of an entrance into a building, the earthwork mound continuing to the southwest presumably representing the continuation of the wall line. The purpose of the building is not apparent, but a deliberate dump of large slag pieces within the entrance would suggest that it became redundant prior to the works going completely out of use. The wall survived to a maximum height of 1.50m and it had been constructed in a foundation trench that cut through deposits of slag and clay (6004, 6007 and 6012). It had clearly been built cutting into and overlying the base of the same large slag deposit (4012) that was recorded underlying the structural elements in trench 4. A single piece of blast furnace slag was recovered from 6007.

These may be the remains of one of the buildings depicted in the 1810 sketch of the site (figure 4). The buildings have a ramshackle appearance and to have been partially

timber clad. The wall here may have been the foundation wall of one of these buildings.

The Finds

Conventional “finds” from the excavations were surprisingly few and too broad in terms of their date range to be useful for the dating of specific areas or activities, i.e. they are broadly 18th and early 19th century. Apart from building materials and industrial residues (see below) finds consisted of animal bone, oyster shell, clay tobacco pipes and window and vessel glass. Ceramics included creamware, slipware, tin glazed earthenware, presumably fairly local hollow-wares (pancheons), north Devon gravel tempered wares (again pancheons) and ubiquitous “china” or decorated whitewares and pearlwares.

See below for discussion of the industrial residues.

Discussion

The excavation at New Weir, though limited in extent, has in some ways posed more questions than it has answered. Nevertheless it has without doubt demonstrated the importance and potential of the remains at New Weir and demonstrated the good levels of preservation of the site.

When combined with the documentary evidence the preservation of the physical remains makes this a significant site. Although the most recent structures such as the hearths in trenches 1 and 4 have been almost completely dismantled enough survives to be able to identify them and to record their dimensions. More importantly sampling has demonstrated that residues survive associated with these structures that are able to tell us a great deal about their functions and use.

The industrial residues, or slag, are another extremely important physical component of the archaeology of the site. This is so both in terms of the quantity of the material (influencing the topography of the site) and what the different materials can tell us about the processes being carried out (see the evaluation of metallurgical residues below). Relatively little is known about the by products from a charcoal forge of this date, very often later industry or development has removed this type of evidence from industrial sites. At New Weir however the end of the use of the site, in the early 1800s or before, its specific location and its complete abandonment have led to the preservation of material from the iron forging process.

The stratification of these deposits (buildings constructed on slag dumps) and the likelihood of good stratification within the deposits and possibly containing datable artefacts add considerably to the significance of New Weir. There is also the potential for the preservation of structural elements of earlier works within and under the slag heaps. In particular the waste deposits may hold the answer to one of the key questions of whether the site was once that of a blast furnace, as has been suggested in various documentary sources. Blast furnace slag was found in some contexts (see evaluation of metallurgical residues below) and although this is clearly residual the

quantities suggest that it might have originated somewhere on the New Weir site. There may thus be a good chronological sequence of processes preserved, perhaps from blast furnace to forge. In addition the forge pond is likely to contain a sediment sequence that may hold both residues and possibly artefacts. There is also the possibility of preserved timber artefacts and machine components in what are probably waterlogged conditions within the pond area (this also applies to wheel pits and water channels).

In terms of understanding the site layout, some progress and clarification has been achieved. Through detailed site inspection and comparison with the documentary sources we now know where both the forge pond and the rolling mill are. The likely area of the forge is also known but was not able to be confirmed by excavation. Excavation has however shown that at least one hearth was located in the riverside range close to and was probably associated with the rolling mill. Additionally a phase of smithing activity has been identified in an area that was previously an open working area adjacent to the forge pond and that appears to have functioned as a quay.

Substantial excavation would however be required to fully understand the water management system. Clearly the water was held in the forge pond and fed two wheel pits associated with the rolling mill (figure 3) these pits emptied directly into the river and this was again confirmed by visual inspection of the river bank. There is a certain amount of evidence for there being water channels on either side of the later smithy building and logically for those continuing on either side of the forge building. We know that the water exited the works through an arched culvert, however how (and where) it was utilised in between the forge pond and this is not clear. A number of wheels would have been required to power the two hammers and the individual bellows for the three hearths mentioned in the documentary sources. It was suggested above that the structure revealed in trench 2 might be associated with water management but this has not been proved beyond doubt.

Geophysics was successful in identifying areas of industrial residue and contrasting wall lines. Two quite large distinct magnetic anomalies were recorded in the centre of the survey area and within the area defined by the early maps as the forge. These may be the sites of hearths though this was unable to be tested during the current project.

The relevance of the site to current research agenda was summed up by David Cranstone in his assessment of New Weir at the start of the project (Cranstone, 2009). He said “The iron industry was a major player in the Industrial Revolution (however defined), and also in the social, economic and landscape development of the Forest of Dean and surrounding areas such as south Herefordshire. The importance of the forge sector (both primary bar iron production and secondary trades such as wire-drawing and tinsplate manufacture) is particularly highlighted in the Historical Metallurgy Society’s research framework document (Bayley et al 2008, esp. 68-70). The importance of the Forest of Dean iron industry (of which New Weir forms a part, though technically outside the Forest) is also highlighted in the Regional Research Framework for Southwest England (Webster (ed) 2008, 234-5, 288). New Weir is clearly important for the achievement of these priorities.”

Acknowledgements

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Tim Young carried out the geophysical survey, gave invaluable advice on the metallurgical residues and sampling strategy and provided the Evaluation of metallurgical residues (below). Various staff from Herefordshire archaeology assisted with the excavations the supervisors were David Williams and Lara Bishop, further assistance was provided by Chris Atkinson, Nigel Baker, Ian Bapty, Moira Cassidy, Natalie Cook, Tim Hoverd and Neil Rimmington. Keith Ray provided guidance and advice throughout the project.

Site archive

1. Site notebook
2. Photographs
3. Site drawings
4. Drawing Catalogue
5. Context Catalogue
6. A Summary Excavation Report (2009)
7. This document
8. Assorted samples and finds

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Validation

Herefordshire Archaeology operates a validation system for its reports, to provide quality assurance and to comply with Best Value procedures.

This report has been checked for accuracy and clarity of statements of procedure and results.

Dr Keith Ray, County Archaeologist

Evaluation of metallurgical residues from New Weir Forge, Herefordshire
Dr T.P. Young

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Abstract

Material from New Weir forge, Herefordshire, comprises micro-residues and some macro-residues from bulk sampling, together with limited collections of hand-picked macroscopic slag from stratified contexts.

The assemblage provides a good cross-section of the macro- and micro- archaeo-metallurgical residues produced by a 17th-18th century finery forge. Such residues are currently poorly known and this assemblage has enormous potential to address these shortcomings.

The overall collection has three main components: - a sparse assemblage interpreted as being mainly from smithing from Trench 1, - a rich assemblage from Trench 3 including material believed to have been produced both during the fining process and during the subsequent compaction of the loup (bloom) - an assemblage of coarse hammerscale, from Trench 4, believed to be associated with the heating of billets for rolling.

In addition to the material from the forge itself, early deposits in trenches 3 and 6, together with sporadic material from Trench 1, contain examples of blast furnace slags, which probably provide the first physical evidence for the operation of a blast furnace on this site between c. 1575 and 1616-1623.

Methods

The submitted materials included a variety of material besides archaeometallurgical residues. The assessment has not examined samples wholly of other materials.

All investigated macroscopic materials were examined visually, using a low-powered binocular microscope where necessary and recorded to a database.

The bulk samples were weighed, wet sieved at 212µm, dried, then separated into magnetic and non-magnetic fractions using a magnet and reweighed. Each subsample was then given a summary description. The residues have not been picked.

As an evaluation, the materials were not subjected to any high-magnification optical inspection, nor to any other form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional.

This project was undertaken for Herefordshire Archaeology.

Results

Description of the residues

Iron-rich slag

The iron-rich slags from New Weir Forge are superficially divisible into five morphological classes plus a 'bucket' category for other materials:

- a. dense flowed slags
- b. slag runners/rods/spikes
- c. dense slag sheets
- d. dense slags rich in moderately coarse charcoal
- e. dense slags with bowl-like morphology
- f. others

Some of these classes are closely-related and some slag pieces may show regions of more than one morphological class.

a) dense flowed slags

These materials include dense, dark, iron-rich slags with the morphology of a prill or bleb (or an amalgamation of such slags) indicating flow of fluid slag.

The major pieces in this group are suggestive of slag accumulation in masses of blebs or prills, but mostly in a form rather different from typical bloomery tapped slags and suggestive of slags that may have dripped, rather than flowed, into the accumulation. This leads to individual components being small, typically equant rather than strongly elongate and often with signs of fragmentation. In addition, the prill masses often show a suggestion of variable prill orientation, indicating that the slag masses may have been deformed when hot – perhaps by raking away from the tapping area.

No complete tapped masses were present in the collection, with the largest fragment (from T3, 010) weighing almost 2kg, but still only a part of a much larger accumulation.

Two examples of dense flowed slags from Trench 2 showed constraint by hard edges: one suggesting slag flow in a curved channel, possibly with a metal margin and the other showed accumulation of flowed slags against a sub-vertical margin.

b. slag runners/rods/spikes

Broadly rod-like slag pieces were a very common feature of the slag assemblage from New Weir Forge.

They are rather variable in detail, with varieties with a sub-circular cross section (*rods*), which often taper markedly (*spikes*), but also with varieties with a flat top, suggesting the flow channel was not filled (*runners*). The terms *rods*, *runners* and *spikes* are used here for practical differentiation within the assemblage, but are not established or acknowledged terms in general use in archaeometallurgy, at least in these narrow definitions.

Several examples show multiple, sub-parallel, rods or runners. This is a very important observation for the interpretation of the precise origin of these slag pieces – and may suggest that the entire length of a ‘rod’ was not formed within a tap-hole blocking, but that they may have formed through rodding through a bed of charcoal, ash, or even of hearth slag.

One specimen (from Trench 3, 008) weighed 3.1kg and had a somewhat conical mass of slightly blebby, granular-appearing slag, out of which arises a stout (40mm diameter) rod, with the fractured base of a probable second rod adjacent. Such pear-shaped slag blocks may be behind the use of the term ‘hambone’ for some forge slags, although that term has not been satisfactorily defined.

c. dense slag sheets

The items assigned to this category show a rather granular slag, often with abundant fine charcoal debris, passing outwards into a much denser, sometimes crudely layered, slag with a planar to slightly curved outer face.

In most cases, although the outer surface is planar, it is rough.

d. dense slags rich in moderately coarse charcoal

This group of specimens includes material with an iron rich slag binding together pieces of charcoal, in some cases with the dense slags showing a lobate or prilly texture, indicative of downward flow of the slag through the fuel bed.

None of these specimens showed a clear original margin, although one specimen did appear to have a plano-convex ‘bowl’ form.

e. dense slags with bowl-like morphology

One substantial specimen of nearly 2kg (from Trench 3, 008), together with some less-certain fragments indicate slag development with a dense bowl-like form, overlain (with an intervening void) by less dense, charcoal-rich slags. The deep bowl was at least 60mm deep and contained tubular vesicles.

The overall morphology of this piece resembles large examples of smithing hearth cakes (SHCs), although the precise mechanism of origin of some of the comparative material (e.g. the large SHCs described by Young 2009) remains uncertain.

f. others

Much of the slag present on the site occurs in a fragmented state. The macroscopic slag collection described here consists of almost entirely of handpicked 'representative' pieces. None the less, some of the hand-picked material is in pieces which are not readily identifiable, as is the slag present in the bulk samples. Such material includes fragments of flowed material, massive dense slags, highly vesicular paler slags and charcoal-rich textures, alongside small slag pieces in the form of prills, sheets and blebs.

One interesting type of slag that doesn't fall within the categories above is a thin sheet form that occurs when fluid slag coats the surface of a tool or workpiece. These materials are commonly met with in micro-residues and classed as slag flats. Here, a good example of such material occurs in Trench 3, 008, occur as a sheet extending on two approximately perpendicular sheets, just a few millimetres thick, from an angle of just a little over a right angle. The object coated by the slag measured at least 40 x 20mm in cross section, but may, of course, have been much larger. It is not known in this instance whether this was a tool (it seems rather large) or the workpiece (perhaps the edge of a billet).

Iron-poor slag

There are three types of relatively iron-poor slags present in the assemblage.

The first is clinker, the partially melted residue from the burning of coal. This is mainly present as small droplets with a typical maroon surface, seen in some of the sieved samples. There were no macroscopic clinkers identified in the assemblage.

A second iron-poor slag is represented by a single specimen of a charcoal-rich slag from Trench 3, 008. The glassy slag in this specimen is variable in colour from dark to a duck egg green. Such material emphasises the problems associated with the interpretation of charcoal-rich materials, and although such a piece might most likely be a low-iron slag from, for instance, a chafery, it could also be a charcoal-rich slag from a blast furnace.

The third low-iron slag type can be attributed to an origin in a blast furnace with a much higher degree of certainty. The slags are pale green, dark green or lilac grey coloured glasses. The larger pieces show a flow thickness of about 60mm, with a slightly charcoal dimpled base. Many of the pieces show some degree of devitrification.

Micro-residues

Wet sieving of the supplied soil samples has generated some interesting collections of micro-residues.

The micro-residues here are mostly materials from the hot working of iron, that are referred to in the archaeological literature as hammerscale and in the modern literature as millscale, reflecting the dominance of the hot working of ferrous materials by rolling in modern industry. Essentially the material has a common origin – the oxidation of hot iron in air. The oxidation will generate superficial layers of various iron oxides, which may then split from the workpiece (through differential thermal contraction or deformation) as flake hammerscale. If iron is to be welded, then the iron needs to be either hot enough that the surface oxides melt, or sufficiently hot that they can be melted with the addition of a flux (typically quartz sand). In either case, forming the weld squeezes the two layers of iron together and the molten oxides will be forced out by the impact of the hammer, with the jet of molten material typically chilling in flight to form spheroidal hammerscale. Spheroidal hammerscale may also be generated during compaction of a bloom containing residual slag. The compaction of the bloom is effectively a welding operation and the molten entrained slag is expelled forcibly.

The material will be described as hammerscale here, although, as discussed later, some might derive from the rolling and slitting processes. One group of micro-residue samples comprises those from Trench 1, contexts 010,027, 029 and 031. These samples are characterised by a rather moderate amount of fine flake hammerscale, but relatively abundant, but very small, spheroidal hammerscale.

Deposits from the upper levels of Trench 1 (context 009) locally contain hammerscale, but in a more conventional assemblage, rich in flake hammerscale.

Good hammerscale assemblages were also recorded from Trench 3 contexts 006 and 008, and, to a lesser extent, context 011. These assemblages produced a large quantity of both flake and spheroidal hammerscale. Some assemblages (particularly from 008) produced a good number of very large spheroids, and at present it is unclear if these are all very large spheroidal hammerscale or whether some may be slag droplets from within a hearth.

The final hammerscale assemblage is that from context 003 or Trench 4. Here the flake hammerscale is extremely thick (up to 2m), with the tripartite layering (haematite-magnetite-wustite layers) even visible with a lens. This assemblage effectively lacked spheroidal hammerscale.

Iron

The submitted materials were rich in iron, much of it in very small fragments and highly corroded. These small fragments are likely to represent losses of iron during the various industrial processes. Corrosion of small iron pieces produced abundant small concretions in some of the bulk samples.

Larger pieces of iron include some that are clearly artefacts (dominantly nails). One large piece of iron has a shape not unlike a cold chisel, but widens towards the possible blade. In general, however, the artefactual ironwork has not been examined.

Trench 6 context 013 produced almost 70 pieces of iron, many elongate and some strongly curved; it is possible that some of this material might be waste from the slitting mill. Some of the corroded iron fragments showed a lack of corrosion on some of the planar faces, but instead a pale surface layer. It is possible that some of these pieces may have a non-ferrous metal coating.

Other materials

The samples contained very little other material directly associated with the metallurgical processes. There were a few brick fragments, but none clearly of metallurgical purpose.

Distribution of the residues

It seems likely that none of the hand-picked macroscopic residues was recovered from any context directly related to its origin. In contrast the micro-GeoArch residues in Trenches 1 and 4 may be indicative of *in-situ* activity.

In Trench 1 the bulk samples provided evidence of hammerscale assemblages in association with small fragments of dark slag. This appears to be directly associated with the location. Trench 1 samples are also noteworthy for the persistent occurrence of small quantities of blast furnace slag.

Trench 2 yielded a small quantity of picked residue material. The majority of these materials were of flowed dense slags.

Trench 3 included several layers of slag deposition (008 & 010) which yielded larger, fresher, pieces of slag than other contexts examined on the sites. These slags included flowed material, 'rods', and bowl-like dense slags. The deposits on the associated floors (006, 011), together with slag layer 008, yielded rich hammerscale assemblages. The original sub-floor below the lowest floor in this trench produced an assemblage of seven pieces of blast furnace slag.

Trench 4 produced a distinctive assemblage with exceptionally thick hammerscale and broken slag debris.

Trench 6 produced a large collection of iron fragments, as well as a piece of blast furnace slag from an alluvial deposit below 004.

Interpretation

It has been argued that the 'Part of a perambulation of the Forest of Dean, May 1634' (Hart 1995) describing 'a certain old weare now utterly ruined built to drive a Furnace of Lord Gray of Ruthen' indicates that the furnace built at Whitchurch by The Earl of Shrewsbury by 1575 was situated at New Weir. The use of 'Lord Gray' (rather the 'the Earl of Kent'), suggests that the furnace had been abandoned before 1623. There has been no reported physical evidence for a blast furnace at this site.

The suggested identification of the New Weir site as that of a blast furnace in the late 16th/early 17th century is now supported by the occurrence of blast furnace slag (in significantly-sized pieces) in early deposits in Trenches 3 and 6, and (as small fragments) through much of the succession in Trench 1. These deposits are not

necessarily (indeed almost certainly not) of the period of the blast furnace, but presumably the ground on which the forge was constructed included quantities of waste from the earlier works.

The forge at New Weir was first clearly attested (Cranstone 2009) in 1684, and in 1695 it is described as being lately rebuilt on an old foundation. There is some disagreement over whether that 'old foundation' was the 1575 blast furnace, or whether there had been an earlier forge on the site. On balance, the lack of clear reference to the site in the mid-17th century and its apparent complete abandonment at the time of the 1634 survey, suggest that earlier references to a forge refer to the 'Old Forge' and that the 1684 reference is to essentially a new build, but utilising aspects of the site and perhaps water management of the 1575 furnace.

The essential core of the forge operation, the fineries and chafery, are represented particularly by the deposits in Trench 3. In the various slag make-up deposits the residues are well preserved, with large fragments of macro-residues and abundant micro-residue assemblages. Most of the macroscopic residues examined are suggestive of finery waste, with dense slags rich in fine-grained charcoal, associated with slag rods of various types and with accumulations of flow-lobed slags probably tapped from the hearth.

The separate finds of planar-based dense slags are probably to be interpreted as the basal residues of the finery – and formed in contact with the iron plates forming the hearth base; it is just conceivable, however, that similar slags might arise in the chafery.

The microscopic residues, dominated by flake and spheroidal hammerscale, do not, in contrast, represent waste from the fining process as such, but from the subsequent compaction of the loop (bloom) and its hotworking down to anchony or bar. Some of the large spheroids may possibly not be hammerscale, but be slag drips formed inside the fuel bed of a hearth.

Identifying possible macroscopic waste from the chafery is more problematic, but it is possible that the large SHC-like slag cakes may be from a chafery. As mentioned above, the planar-based slag sheets might also be from a chafery, but their texture appears to more closely resemble those of slags attached to the slag rods – and hence be indicative of an origin in a finery.

The micro-residues from Trench 4 differed from those of Trench 3, in being dominated by abnormally thick flake hammerscale (up to 2mm). Even with low magnification the layering within the flake is clearly visible. The oxide layer on iron grows through diffusion of oxygen and iron. This process is slow, so a 2mm scale probably requires a heating period measurable in hours – though precisely how long depends on the temperature. Such long heating periods do not tally with the rapid heating and working of iron either in the chafery or indeed the blacksmith's forge. A more likely explanation is that such scale derives from the heating of finished billets from cold, for working under a hammer (to start the plate production process for instance), or for working in a rolling or slitting mill. Given the high level and superficial stratigraphic location of these materials, an origin seems possible in the heating of billets for processing in the rolling mill which is supposed to have existed at New Weir Forge in the later years of its use.

The deposits from Trench 1 contain various disparate items of residue and many of these are likely to be residual, or at least, not associated directly with this area of the site. Some of the pieces may be residues from smithing, but there are no totally convincing examples of smithing slags. The micro-residues present a rather more coherent picture for smithing – although residue assemblages are rather sparse in most cases. The characteristic property of the samples from this trench is the occurrence of unusually fine-grained spheroidal hammerscale. The distribution of such material may sometimes be modified (because of preferential movement of spheroidal hammerscale by earthworms to act as lining to aestivation burrows). The pattern is so consistent in this case it is probably a real feature of the original assemblage. No research has been undertaken on the size of spheroidal hammerscale particles in relation to task, but would seem likely that assemblages of small particles would relate to light forge welding activities, rather than the processes undertaken within the manufacture of iron. The apparent presence of large amounts of fine-grained iron debris (now largely corroded) might also relate to smithing activities.

Evaluation of potential

Present understanding of 17th-18th century finery forge residues is very poor. Uncertain discrimination of late bloomery and finery slags bedevils some early accounts. On other sites, the overlaying of ‘new’ late 18th-19th century technologies upon earlier works again makes certain assignation of residues to particular technologies difficult. Compositions and mineralogies of some finery slags were provided by Gordon (1997), but these are for late, North American, examples and may not be representative of earlier European techniques.

The assemblage from New Weir Forge includes both macro-and micro- residues employed as floor make-up deposits within the forge building. This material appears fresh and relatively unaltered and so is likely to have been deposited (either directly or secondarily) soon after its production. This material is currently interpreted as containing both finery and chafery residues. The documentary evidence seems to suggest (Cranstone 2009) that New Weir Forge was operated in a rather conservative manner and therefore the fining wastes are likely to pertain to a straightforward Walloon-style finery. The collected samples from Trench 3 provide a small, but varied group of materials, from securely stratified contexts. The major slag types: granular sheets, charcoal-rich hearth slags, rods/runners/ tapped slags and plano-convex cakes are all present within the collection.

The macro-slugs from Trench 3 are also accompanied by micro-residue assemblages, including hammerscale. It is assumed that these micro-residues, like the associated macro-residues, derive from the fining and related bloom-compaction processes. Contrasting morphologies of micro-residues were recovered from Trench 1 (interpreted as deriving from smithing) and Trench 4 (interpreted as deriving from billet heating for rolling/slitting).

The assemblage is limited in size and does not derive from contexts directly related to the metallurgical hearth or furnaces. None-the-less, the stratigraphic control and the association (particularly for the micro-residues) with particular parts of the structure, means that the assemblage has a very high potential to contribute to understanding of the finery forge. Cranstone (2009) has already indicated the significance of improved

understanding of the finery forge to the national research strategy (Bayley *et al.* 2008). Improved understanding of the residues will also feed back into improved understanding of the excavated structures.

The potential of the assemblage from the forge could be realised through sampling and analysis (both bulk chemical and micro-textural) of representative material of the major macroscopic and microscopic residue classes. In addition, some analysis of the pre-forge blast furnace slag would also have potential for interpretation of the resources employed in this earlier phase of activity on the site.

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